Contribution of land transport emissions to ground level ozone, calculated by means of a multiply online nested model

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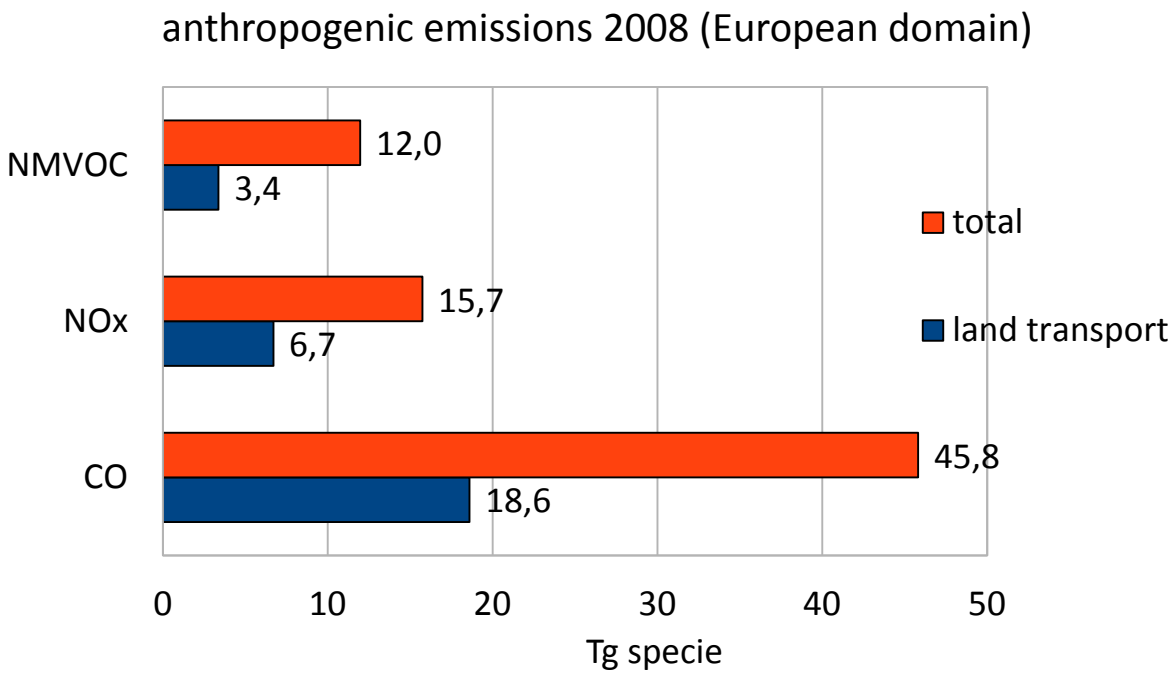
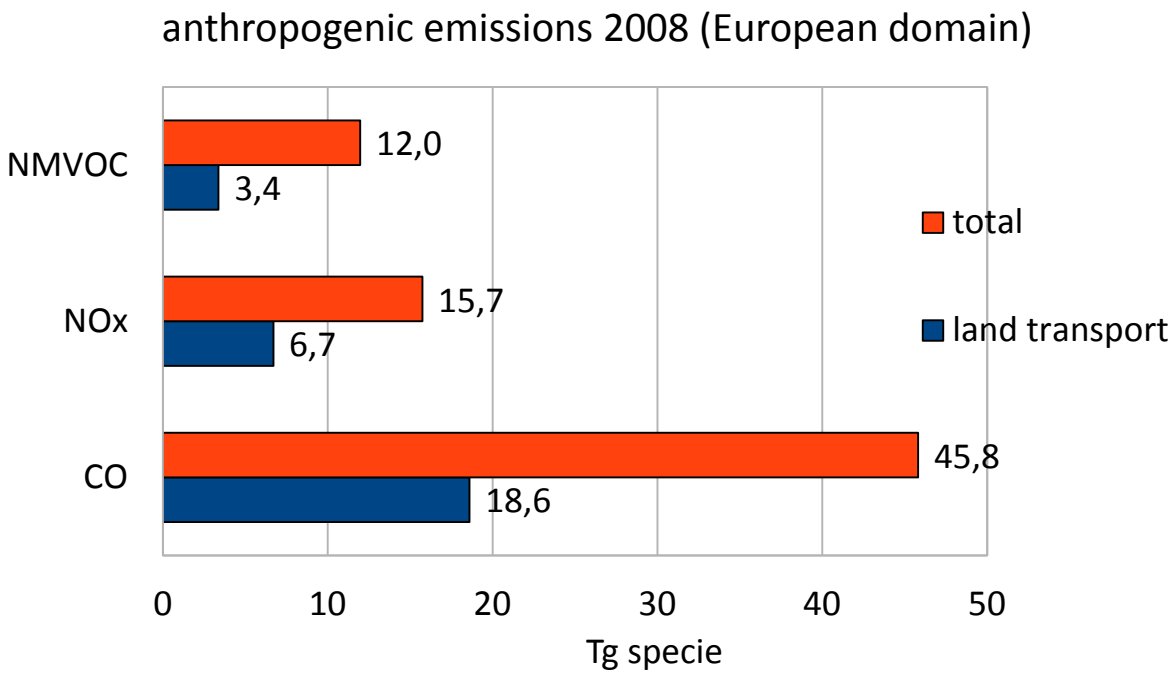
Land transport emissions in Europe

- Nitrogen oxides, volatile organic compounds and carbon monoxide are precursors for ozone
- Land transport is a significant source of these precursors
- Production of ozone is highly non-linear



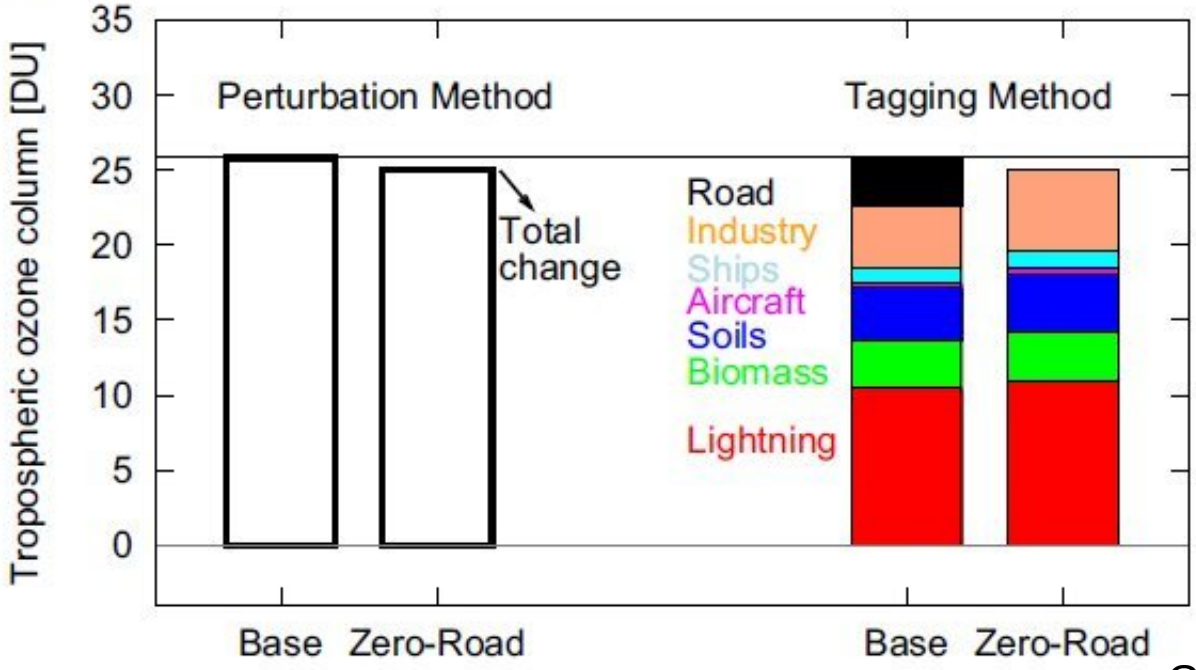
Getting serious: Land transport emissions in Europe

What is the contribution of land transport emissions on tropospheric ozone?



Contribution vs. impact

- **Contribution**: Amount of ozone produced by emissions of a specific source
  Source apportionment method (e.g. tagging method)
- **Impact**: Change of ozone, if emissions of specific sources are decreased
  Sensitivity method (e.g. perturbation method)



Grewe et al., 2012

Tagging method for source apportionment

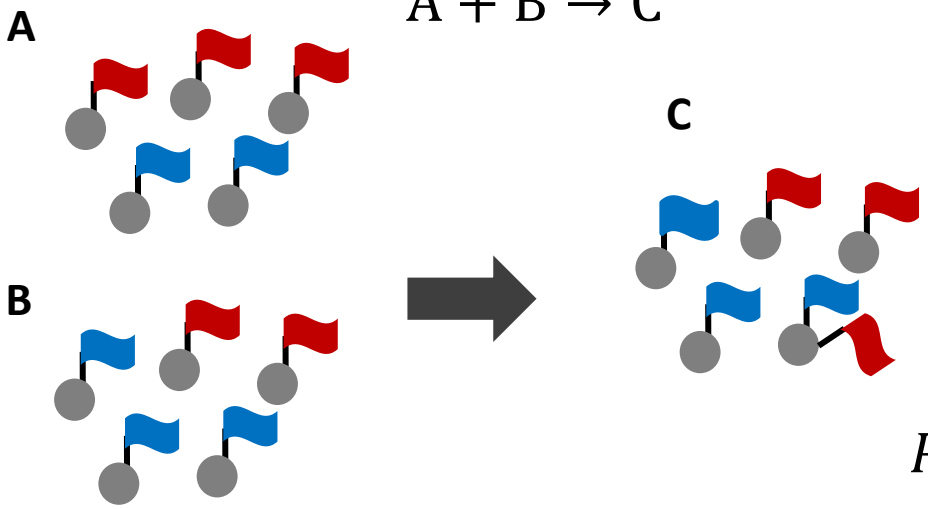
- Diagnostic method using a combinatoric approach considering O_3, NO_x, CO and VOC *(Grewe et al., 2010, 2017; Tsati, 2014)*
  - considered chemical species are fully decomposed (closed budget)
  - family approach for computational reasons

$$\sum_{tag=1}^{N} O_3^{tag} = O_3$$

Emission sectors:
land transport
industry

Example:

$$A + B \rightarrow C$$

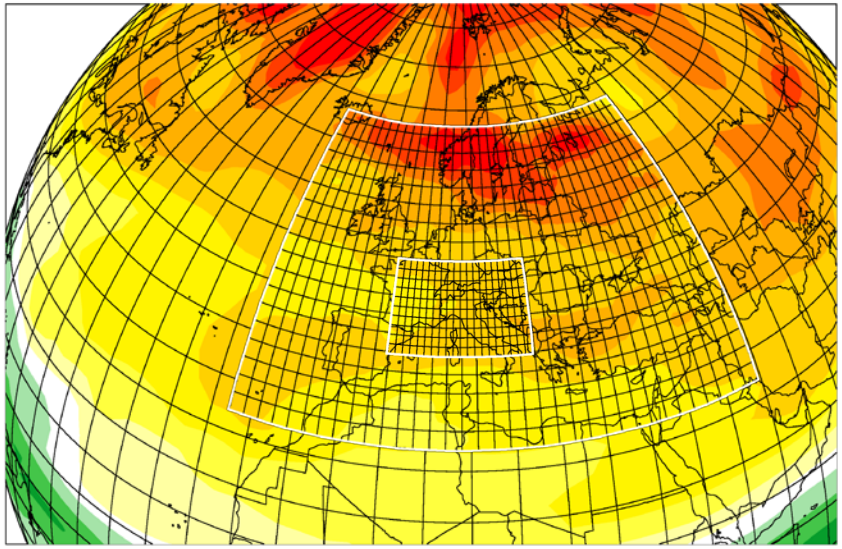


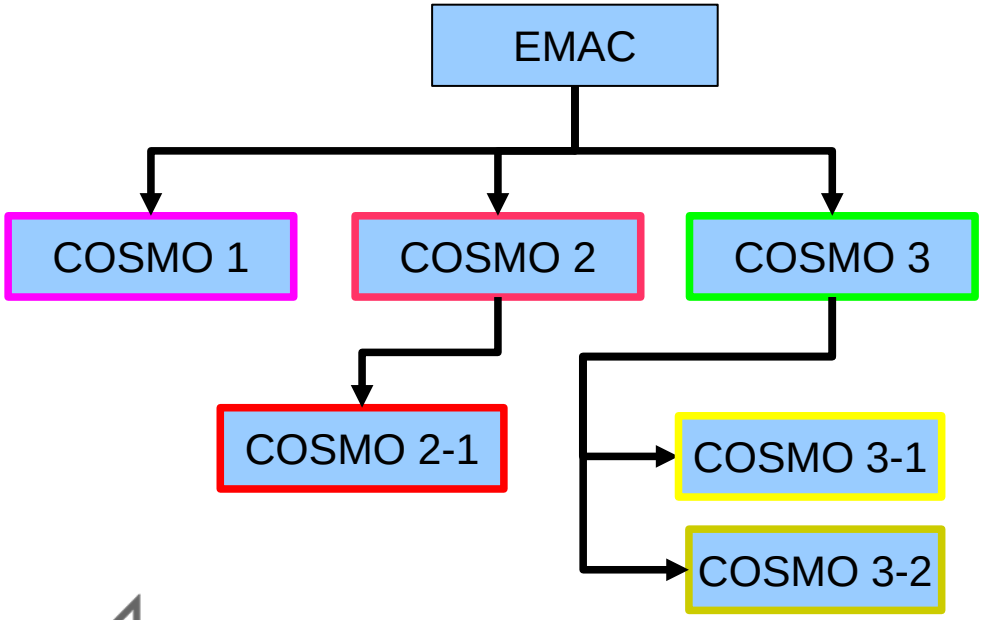
1. $A + B \rightarrow C$
2. $A + B \rightarrow \frac{1}{2}C + \frac{1}{2}C$
3. $A + B \rightarrow \frac{1}{2}C + \frac{1}{2}C$

$$P(C^{tra}) = \frac{1}{2} k\, A\, B \left(\frac{A^{tra}}{A} + \frac{B^{tra}}{B} \right)$$

MECO(n): MESSy-fied ECHAM and COSMO n-times nested

- 1-way on-line nested global-regional atmospheric model system
  - EMAC as global model
  - COSMO/MESSy as regional model
- Meteorological and chemical (incl. contributions) boundary conditions
- Allows for a consistent “zooming” into specific areas.

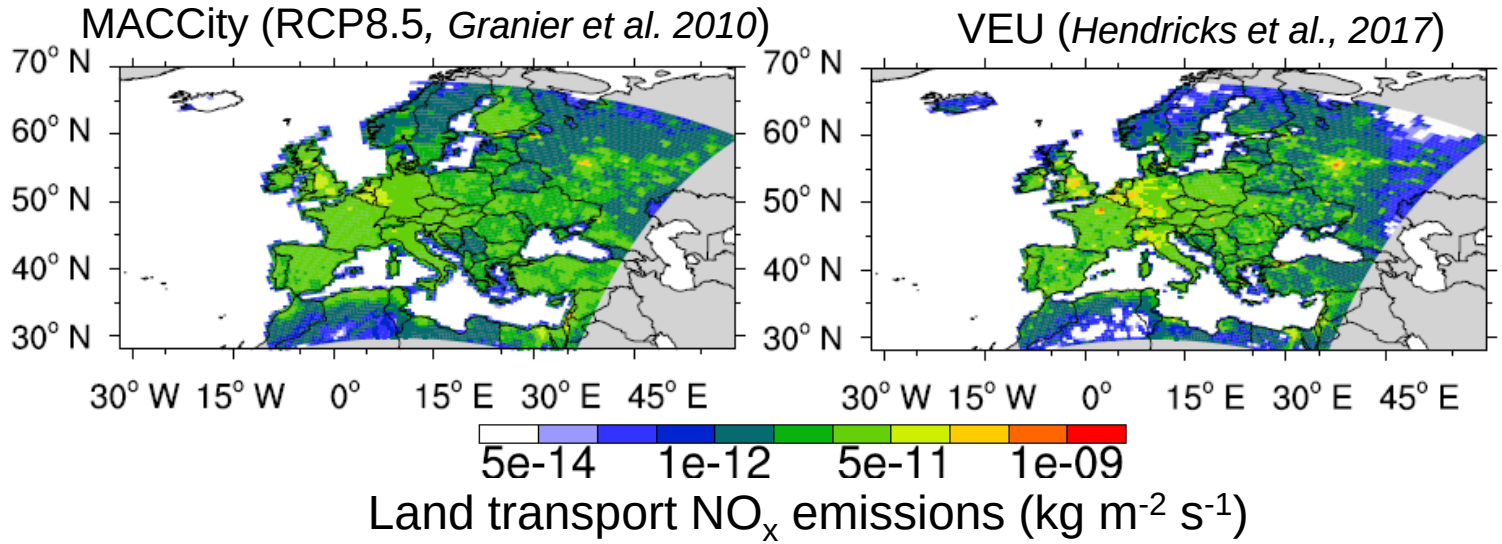




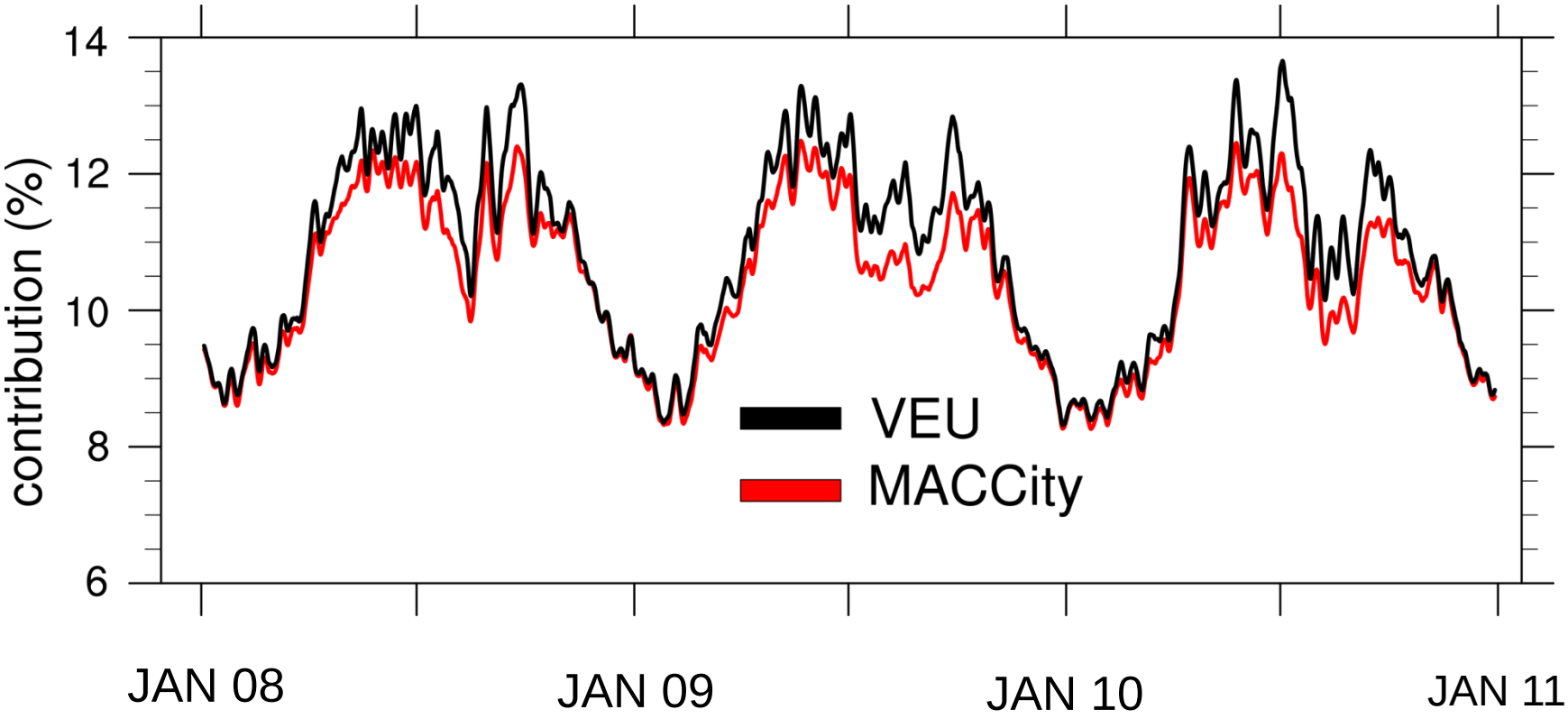
Kerkweg & Jöckel, GMD, 2012a,b
Hofmann et al., GMD, 2012
Mertens et al., GMD, 2016

Setup of the model system

- MECO(2)
  - Global: EMAC resolution T42L31ECMWF (~300 km resolution)
  - Europe: COSMO ~ 0.44°x0.44° (~50 km)
  - Germany: COSMO ~ 0.10°x0.10° (~12 km)
- Simulation period 2007/07 – 2010/12 (2008 – 2010 are analysed)
- Chemical evaluation with various observations *(Mertens et al., 2016, GMD)*
- Two simulations applying different emission inventories in COSMO
  - Identical emissions are applied in EMAC (MACCity)

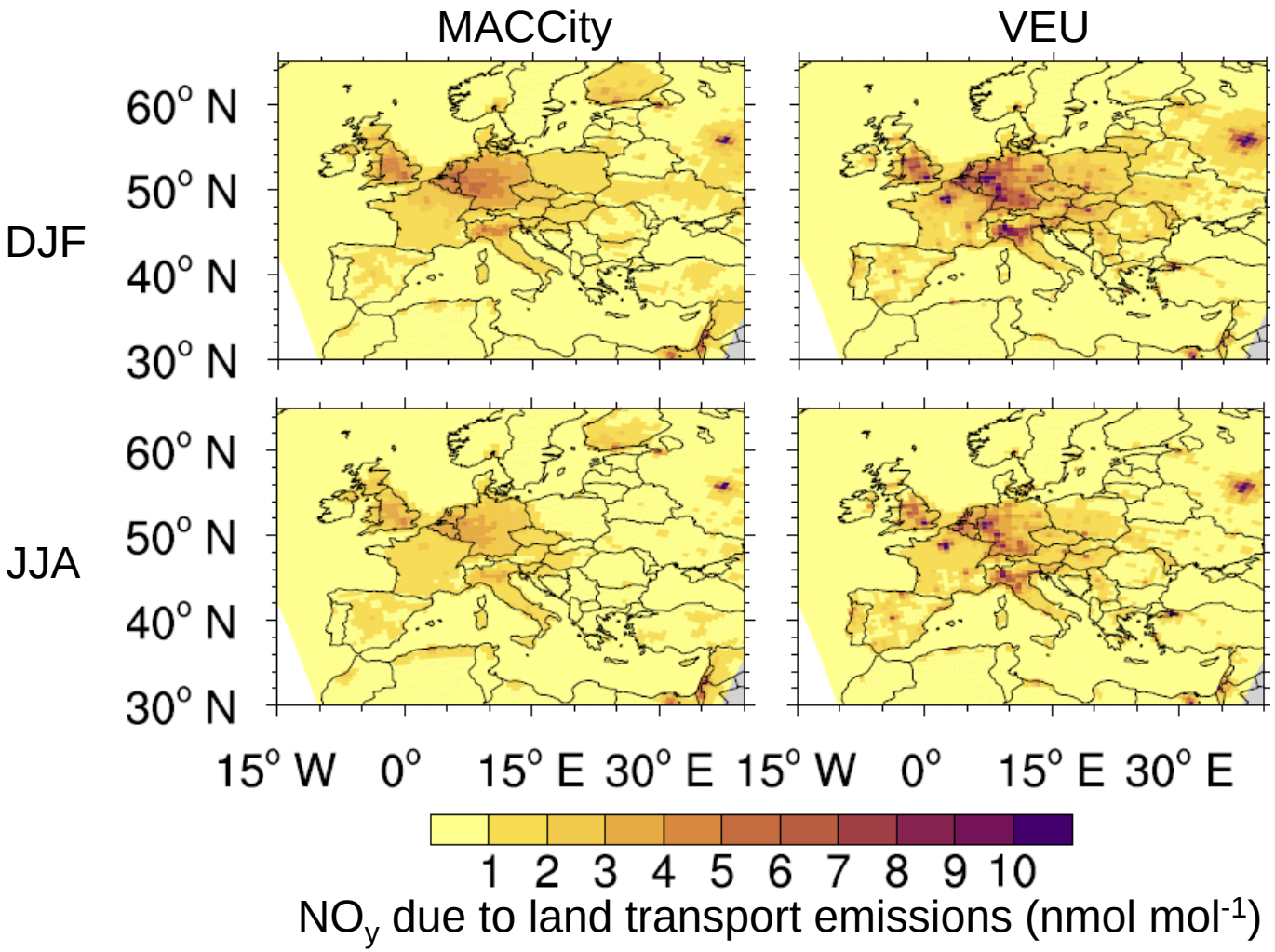


Average contribution of land transport emissions to ozone over Europe

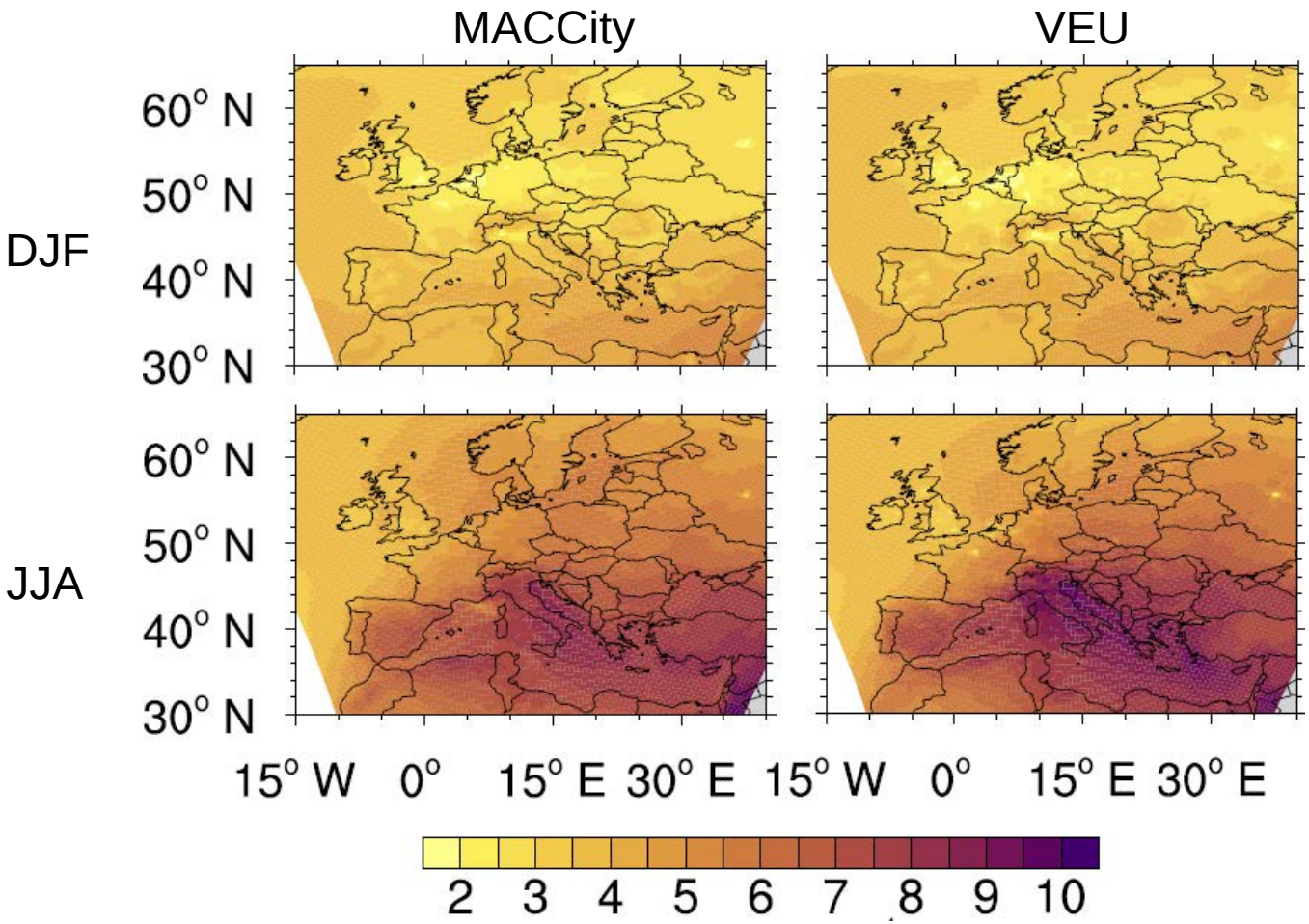


Area averaged relative contribution (in % for Europe, 50km resolution) of land transport emissions to the partial ozone column from the surface up to 850 hPa.

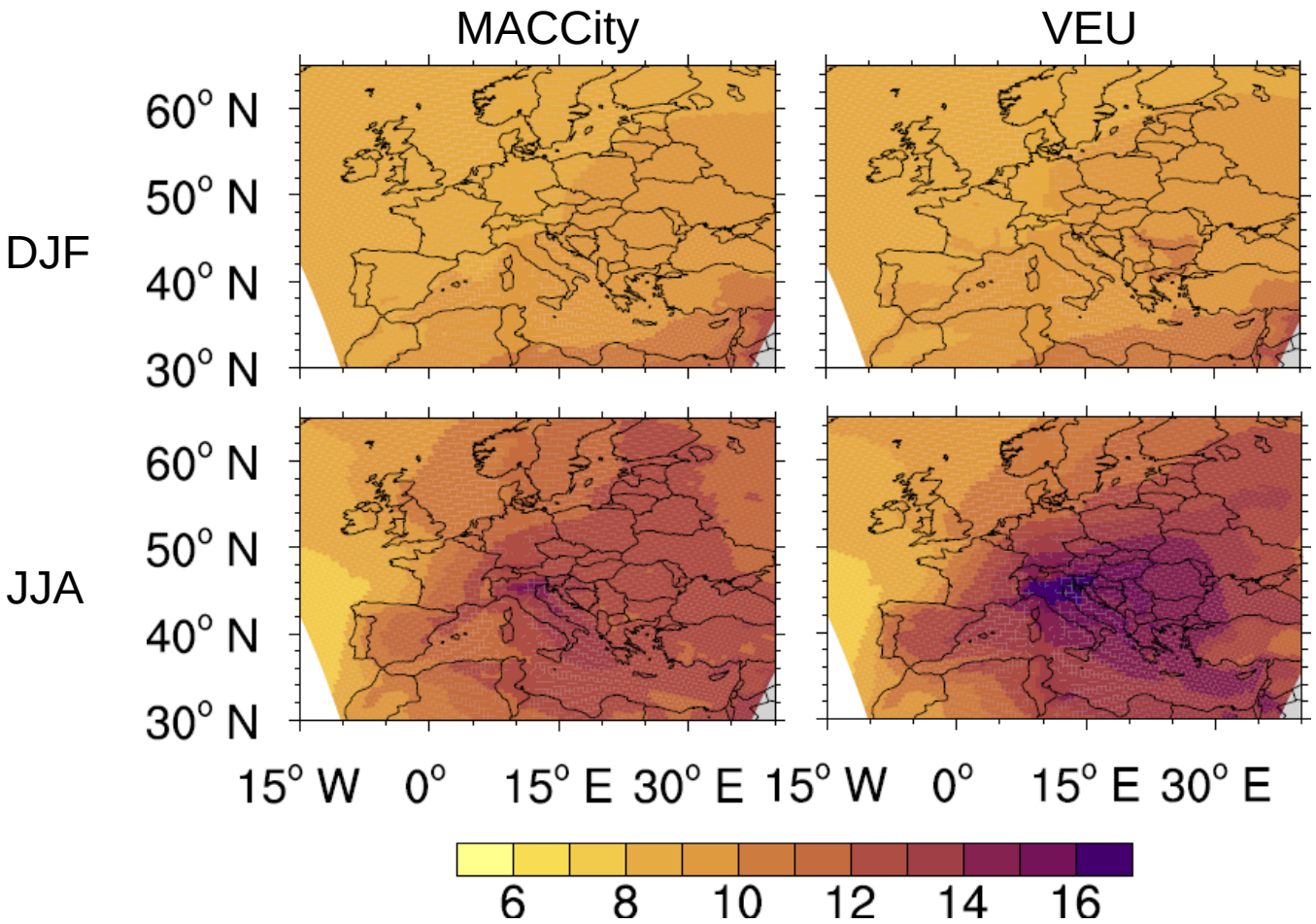
Absolute contribution of land transport exhaust to groundlevel NO_y



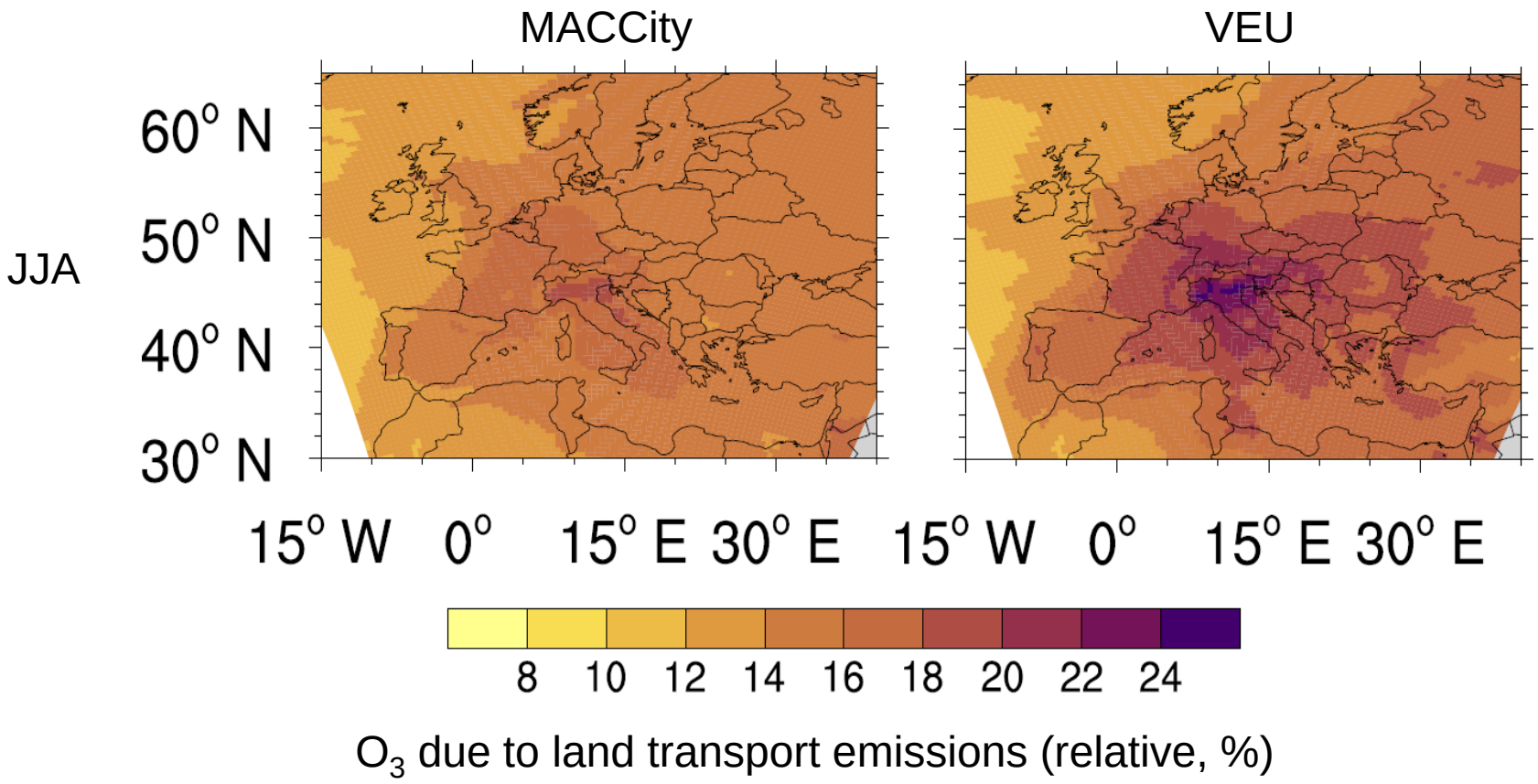
Absolute contribution of land transport exhaust to groundlevel O_3



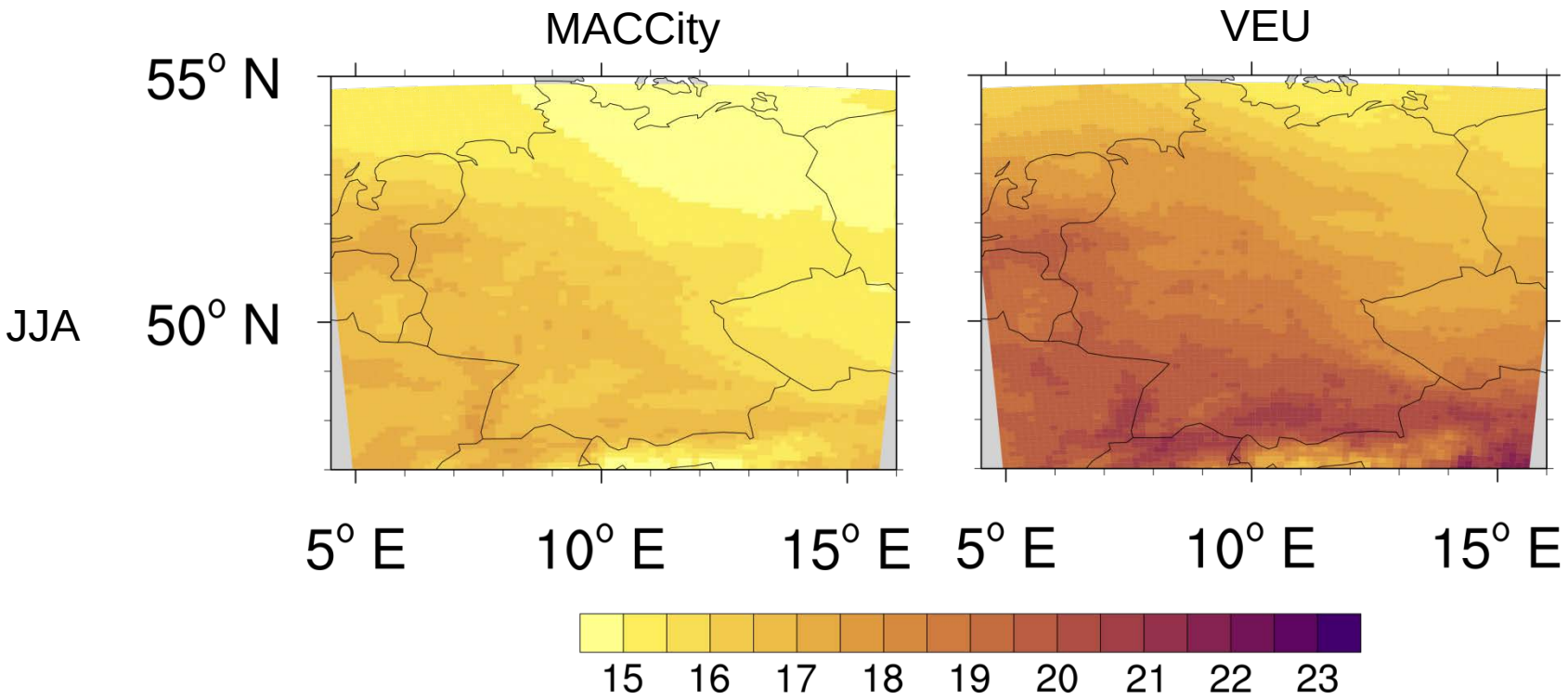
Relative contribution of land transport exhaust to groundlevel O_3



95th percentile of relative contribution of land transport exhaust to groundlevel O_3



95th percentile of relative contribution of land transport exhaust to groundlevel O_3 in Germany (12 km)

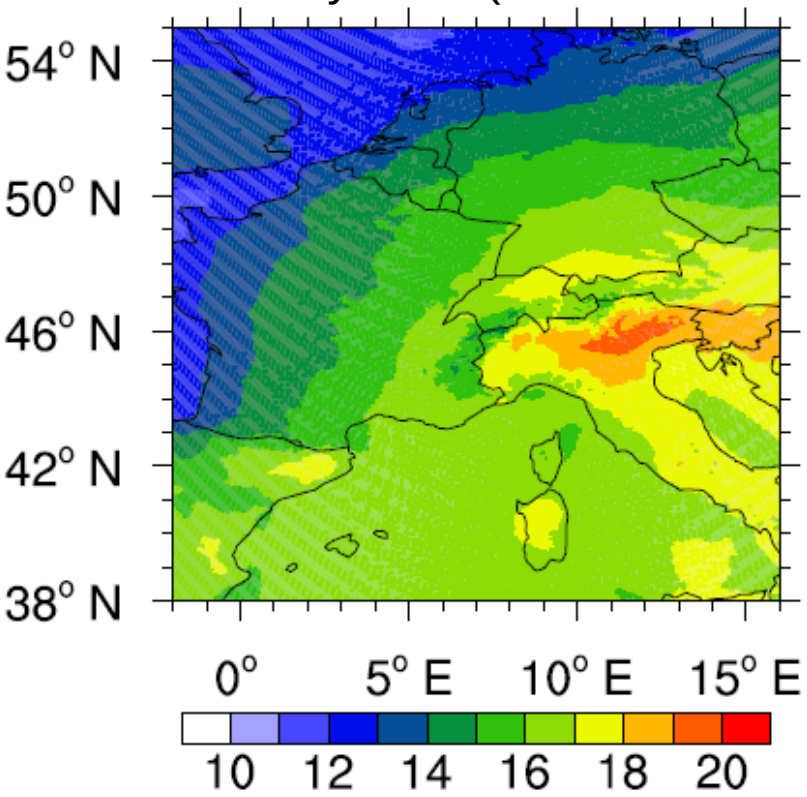


O_3 due to land transport emissions for 2008 (relative, %)

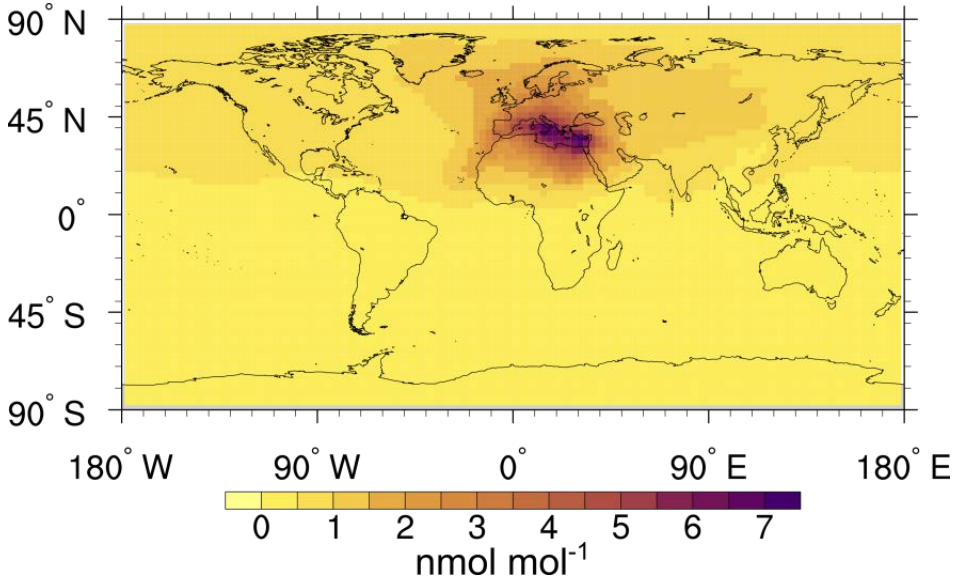
Outlook

MECO(n) is now applied in follow up studies with increasing complexity of the tagging as well as the model resolution

Contribution of land transport emissions to ozone in July 2017 (7 km resolution)



contribution of european land transport emissions to ozone



Conclusions

- MECO(n) model system allows for a consistent evaluation of the contribution of different emission sources on ozone on global down to regional scale
  - Important for air quality as well as climate issues

- Contribution of land transport emissions during summer in Europe

  NO_y: strongly depending on region and emission inventory; 4—10 nmol mol^{-1}

  O_3: on average ~ 11 % (5—10 nmol mol^{-1})

  during summer season in the Po basin up to 15 %

  95th percentile; up to 23 % percent in specific regions

Important: Results refer to ‘regional scale’ not to ‘city scale’